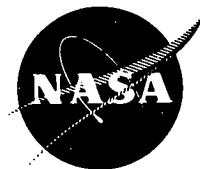


# NASA TECH BRIEF

## *Lewis Research Center*



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### Inhibiting Kirkendall Void Growth in Welded Bimetallic Structures

A new technique has been demonstrated for inhibiting Kirkendall void formation in bimetallic welded structures exposed to high operating temperatures. The technique employs a pre-aged, void-free junction composed of the parent materials.

Dissimilar metals welded together, which are exposed to high temperatures, interdiffuse. Interdiffusion is uneven since atoms of the lower melting point material have a higher mobility and diffuse across the junction more rapidly than atoms of the higher melting point material. This imbalance results in vacancies or voids in the lower melting point material adjacent to the junction, commonly referred to as the Kirkendall Effect. With continued exposure to high temperature, the voids increase and coalesce causing porosity and loss of strength.

Prior research has been directed toward inhibiting or retarding the interdiffusion of the parent materials by placing a layer of a third material between them as a barrier. Barrier layers may reduce but do not solve the void problem. In some applications, such as in thermionic power systems, a barrier layer of a third material cannot be used.

Present research further investigated the interdiffusion process and explored a new approach to inhibiting void formation. Interdiffusion is a parabolic process, i.e., the rate of diffusion decreases as the time of exposure to temperature increases. At the lower rate of diffusion, which occurs after the junction has been artificially aged at higher than operating temperatures, the natural vacancy removal mechanisms (grain boundaries, dislocations, bulk diffusion) adequately remove the voids without their precipitating. Therefore, if a junction can have, initially, the characteristics of an aged junction, the vacancy flux would be reduced and the Kirkendall voids would be reduced in size or even eliminated.

Two methods are recommended to reduce Kirkendall void formation:

1. Annealing the junction at an ultrahigh temperature at which the natural vacancy removal mechanisms are enhanced will result in void-free interdiffusion. Subsequent long time exposure at a lower operating temperature will cause minimal additional interdiffusion and the inhibition of voids.

2. Forming the junction through intermediate layers of graded composition alloys of the parent metals will produce the desired low diffusion rate values.

#### Notes:

1. The basic process for Kirkendall void inhibition can be applied to thermionic power systems, high temperature seals, high temperature junctions between any two metals of differing melting points where Kirkendall void formation would be detrimental; i.e., laminated sheets, bars, bimetallic tubing, etc.
2. The work undertaken on the Kirkendall void inhibition has been limited to basic proof of feasibility involving both experimental evidence and basic theoretical work. However, considerable additional work would be required to reduce the basic feasibility studies to standard technical practice.
3. Further information is available in the following reports:

NASA CR-134490 (N74-34046), Interdiffusion Behavior of Tungsten or Rhenium and Group V and VI Elements and Alloys of the Periodic Table, Volume I

NASA CR-134526 (N75-10209), Interdiffusion Behavior of Tungsten or Rhenium and Group V and VI Elements and Alloys of the Periodic Table, Volume II, Appendices

Copies may be obtained at cost from:

Aerospace Research Applications Center  
Indiana University  
400 East Seventh Street  
Bloomington, Indiana 47401  
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Reference: B75-10006

4. Specific technical questions may be directed to:  
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(continued overleaf)

**Patent Status:**

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